

[54] FIRE CONTROL SYSTEM FOR
MULTI-ZONE BUILDINGS

[76] Inventor: Edward J. Miller, 6702 Church St.,
Morton Grove, Ill. 60053

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[58] Field of Search 98/33 R, 43; 236/49;
169/60, 61; 165/16

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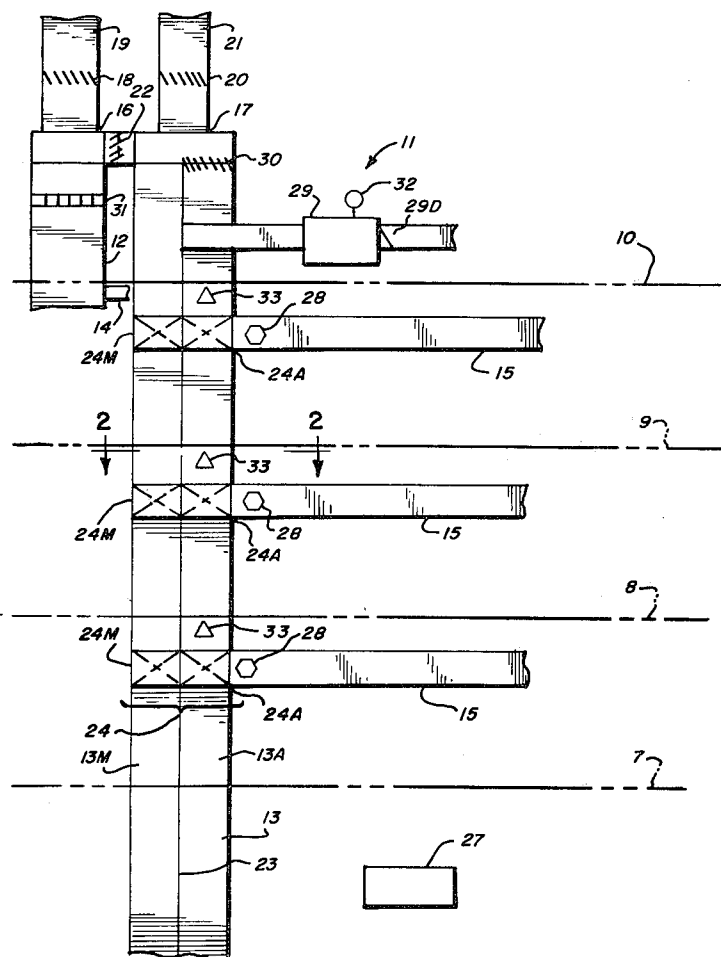
Primary Examiner—William E. Wayner
Attorney, Agent, or Firm—J. Patrick Cagney

[57] ABSTRACT

A method of controlling smoke, ventilation and fire flash point temperature in a multi-zone building served by a central ventilation system uses a divided common return air duct having separate branch damper connections for each zone for directing all return air from a fire zone into one section of the common return air duct for complete exhaust and for directing all return air from a non-fire zone into the other section of the common return air duct.

The method also provides positive pressurization of the non-fire ventilation zones relative to the fire ventilation zones and maximum fresh air to all zones.

14 Claims, 8 Drawing Figures



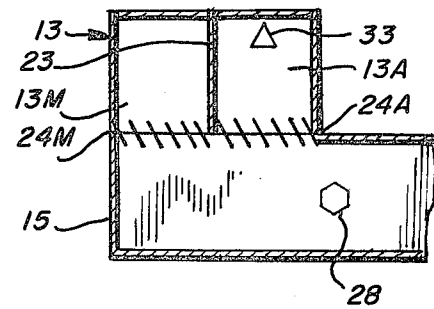
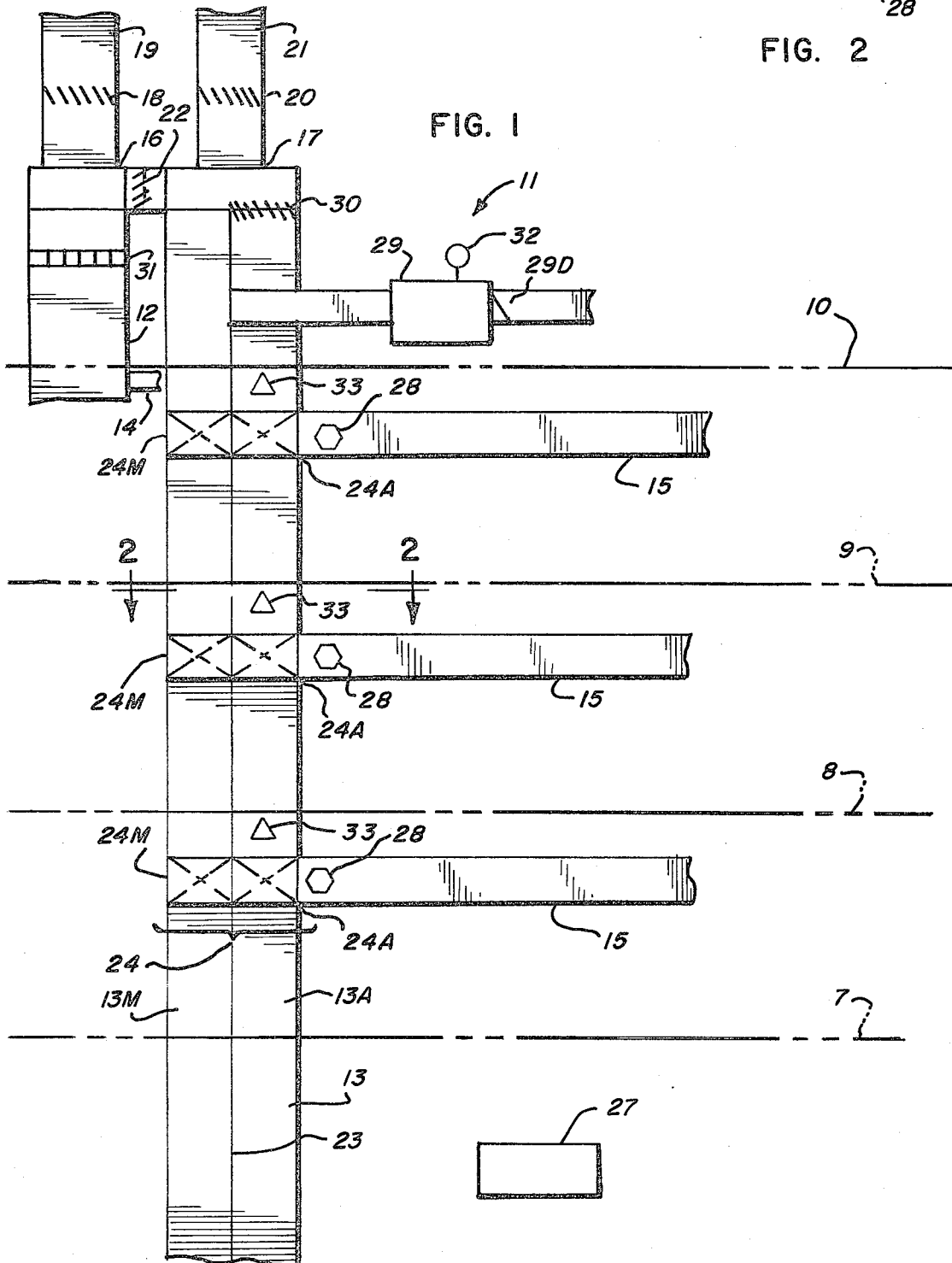
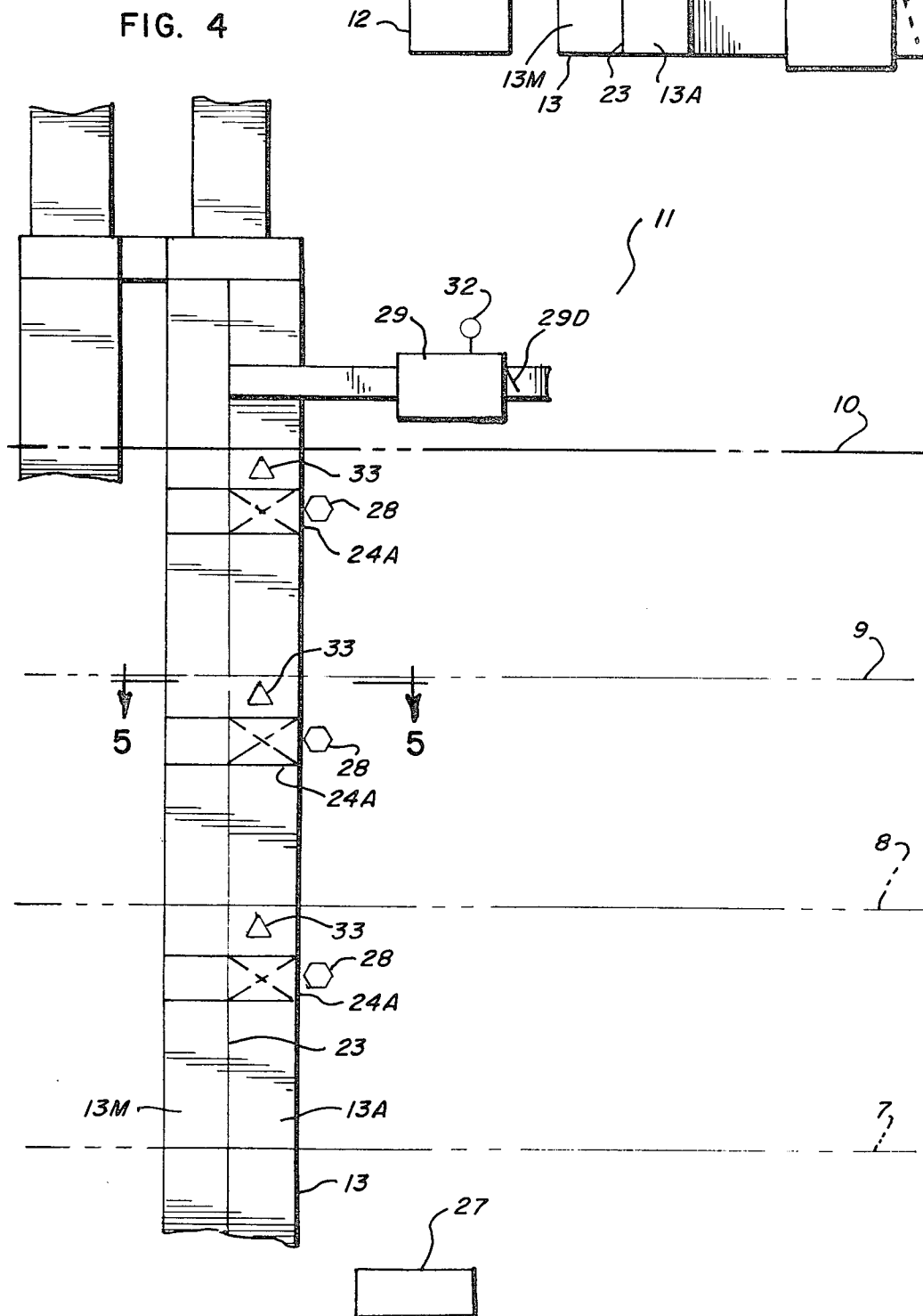
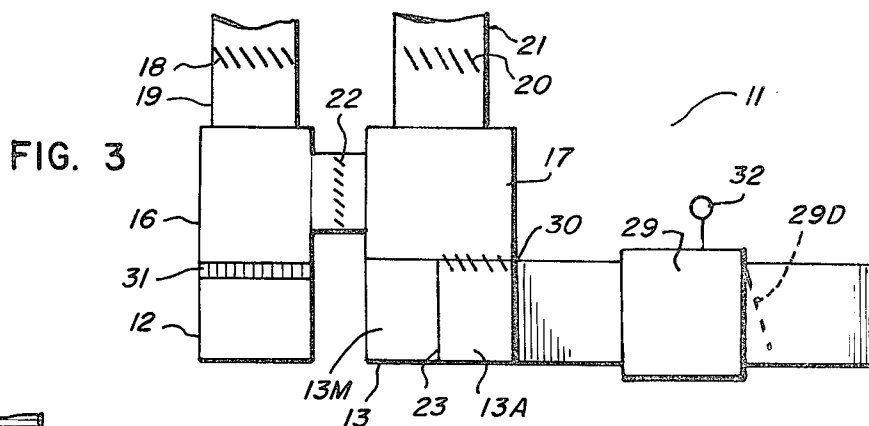
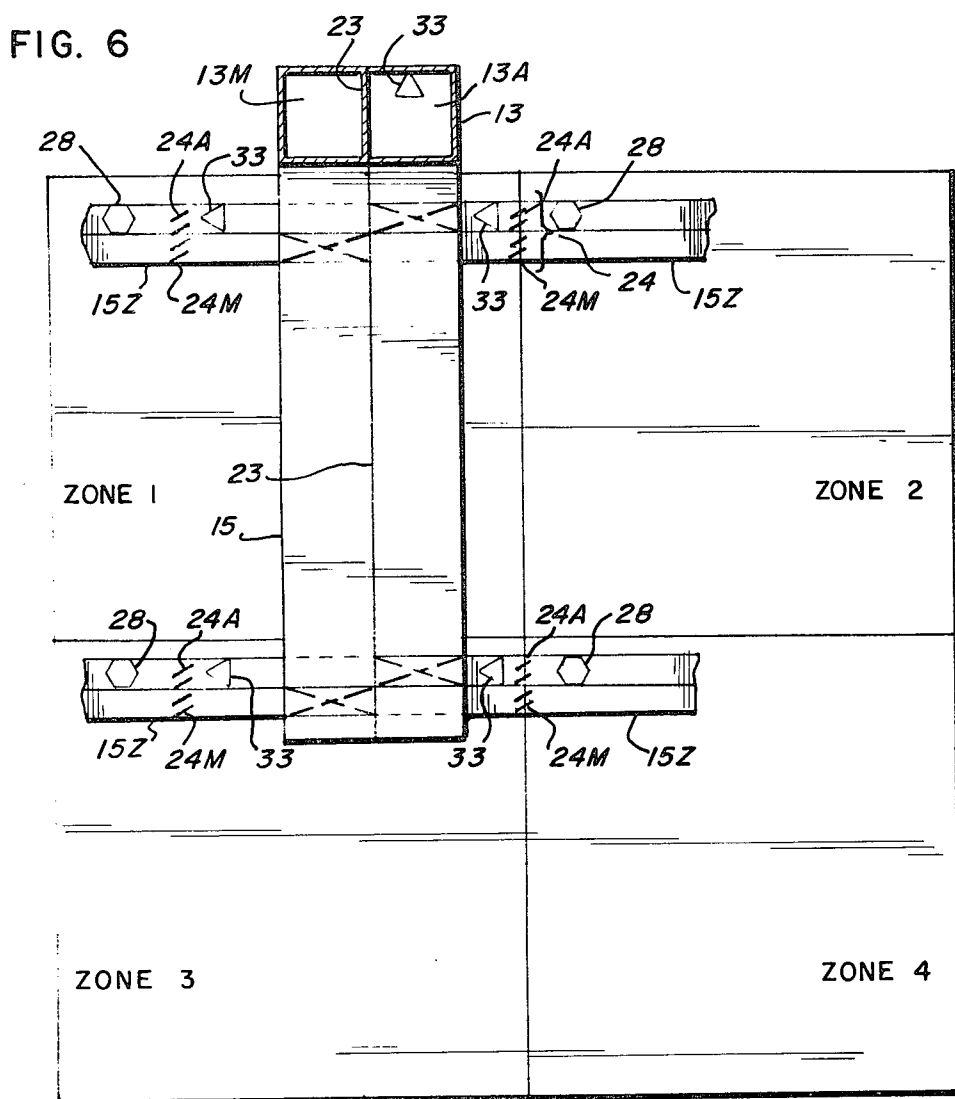
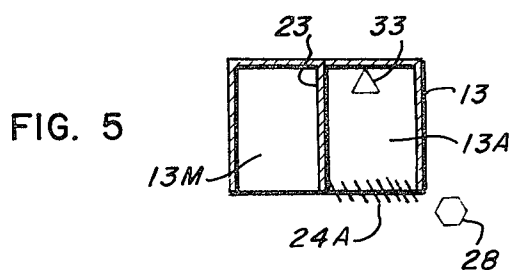


FIG. 2







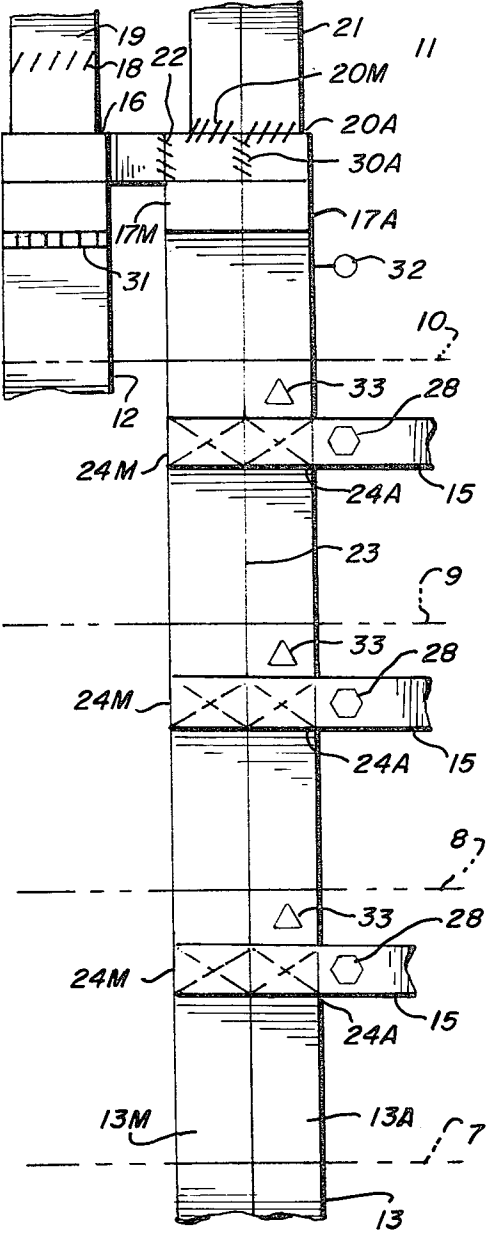


FIG. 7

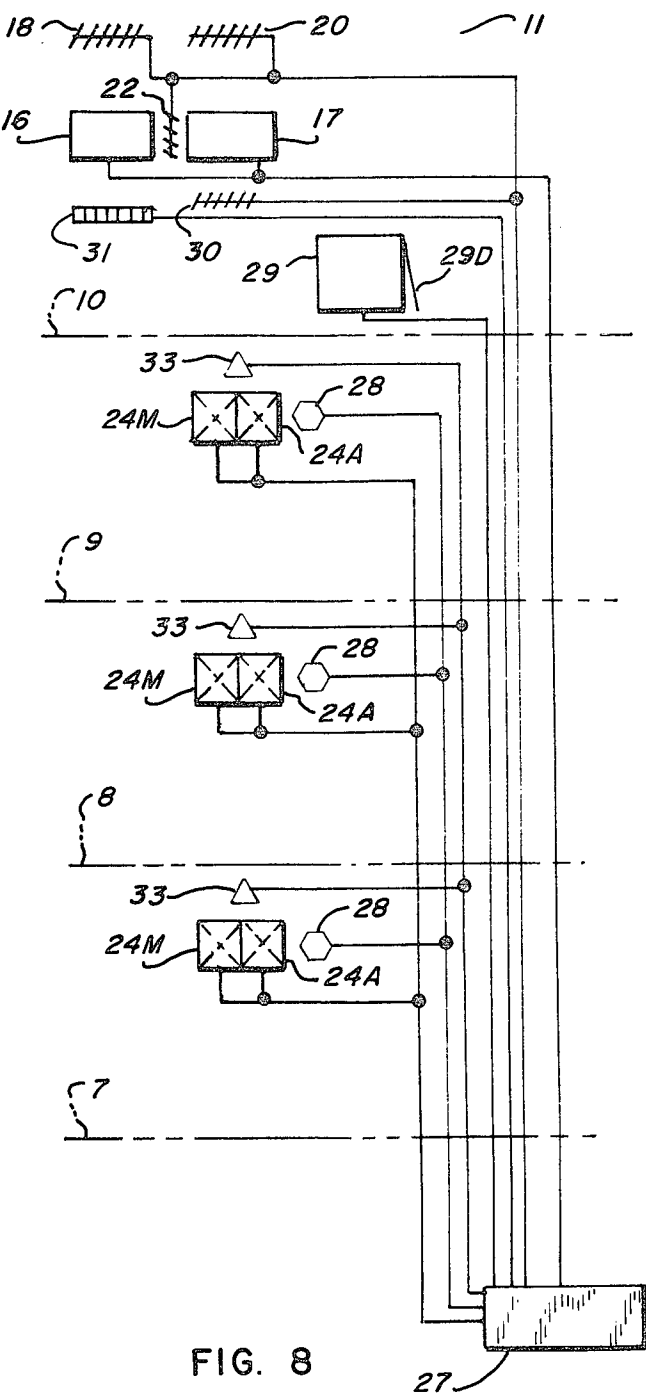


FIG. 8

FIRE CONTROL SYSTEM FOR MULTI-ZONE BUILDINGS

BACKGROUND OF THE INVENTION

This invention relates to fire control systems for multi-zoned buildings, such as high rise office or apartment buildings, that are served by a central ventilation system.

It is generally recognized that effective control of smoke, ventilation and fire flash point temperature requires a system capable of providing

1. maximum pressurization of the non-fire zones together with good exhaust of ambient smoke;
2. maximum fire zone ventilation to prevent flashover temperatures; and
3. maximum fire side exhaust for smoke removal.

There has been a continuing need for a system capable of satisfying these criteria. Even though the importance of adequate fire control for high rise buildings is recognized by all, no truly effective solution has previously been developed.

SUMMARY OF THE INVENTION

The present invention provides a flexible system for controlling smoke, ventilation and fire flash point temperature that is simplified and economical and that satisfies the aforementioned criteria by providing

1. 100 percent air to the fire and non-fire zones;
2. reduced return air from the non-fire zones;
3. a multifold increase in return air from the fire area to exhaust smoke and heat and cause a larger percentage of the total fresh air to be delivered to the fire zone than under normal conditions for fire ventilation; and
4. maximum fresh air to both fire and non-fire zones.

More particularly, the invention provides a method of fire control and ventilation for multi-zone buildings comprising drawing fresh air into the building to form a main supply stream of supply air; subdividing the main stream into branch streams and supplying each branch stream into a separate zone; drawing air from each zone to form a pair of common return air streams; normally exhausting at least some of the air from the return air streams while recycling the remainder into the main supply stream; and responding to fire conditions occurring in any one of the zones to depressurize any fire zone by directing all the air drawn from such zone into one of the return air streams while exhausting all of said one return air stream to pressurize the non-fire zones by directing all the air drawn from the non-fire zones into the other return air stream.

AS applied to a typical multi-zone building arrangement that has a ventilation system including a central station serving a plurality of ventilation zones, common supply air duct means connecting the ventilation zones to the central station, common return air duct means connecting the ventilation zones to the central station, each zone having branch supply duct means connected to the common supply air duct means and branch return duct means connected to the common return air duct means, and the central station including central supply fan means, central exhaust return fan means and main damper means for controlling flow of fresh air

into the common supply air duct means and recycling of return air from the common return air duct means to the common supply air duct means, the improvement of this invention comprises partition means for dividing the common return air duct means lengthwise into a main return air duct section and an auxiliary return air duct section, separate branch damper means for each zone for controlling communication of the branch return duct means of such zone with each of the return air duct sections, standby means for effecting isolation and exhaust of all return air from the auxiliary return air duct section, and control means including separate detection means for each zone operable upon the occurrence of fire conditions therein for actuating the standby means and the corresponding one of said separate damper means for directing all of the return air from any fire zone to exhaust through the auxiliary return air duct section, and for directing all of the return air from any non-fire zone into the main return air duct section.

Additional features of the presently preferred embodiments include: the provision of a standby exhaust fan for connection to the auxiliary return air duct section in the fire mode to exhaust all return air from fire zones; an automatically responsive control system for sequencing the positioning of all necessary dampers both in the normal mode and in the fire mode; the provision of static pressure means for controlling the capacity of the standby means for effecting a pressure reduction in the fire zones; the provision of facilities to enable supply of 100 percent fresh air to all ventilation zones during the fire mode; and the provision of sprinklers for controlling return air temperature.

Other features and advantages of the invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which show structure embodying preferred features of the present invention and the principles thereof, and what is now considered to be the best mode in which to apply these principles.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic vertical sectional view showing a multi-zone high rise building equipped with a central ventilation system incorporating the fire control system of this invention;

FIG. 2 is a fragmentary sectional plan view taken as indicated on the line 2—2 of FIG. 1;

FIG. 3 is a diagrammatic plan view of the central fan room of the ventilation system;

FIG. 4 is a diagrammatic view similar to FIG. 1 and showing the invention as applied to a ventilation system that uses free return flow from a ceiling plenum arrangement on each floor;

FIG. 5 is a fragmentary plan view taken as indicated on the line 5—5 of FIG. 4;

FIG. 6 is a plan view of a horizontal type multi-zone ventilation system;

FIG. 7 is a view similar to FIG. 1 and showing a modified fan system to illustrate other adaptations of the system; and

FIG. 8 is a schematic control circuit diagram for the ventilation systems disclosed herein.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, an improved ventilation system to provide for smoke, ventilation and tem-

perature control in fire management is illustrated in connection with a multi-story building in FIG. 1 wherein 10 designates the floor line for a central fan room at the top of the building, and 9, 8, and 7 designate the floor lines for lower floors of the building, each of which constitutes a separate ventilation zone, in the case of the illustrated embodiment, with all of the ventilation zones being served by a common ventilation system.

Such a common ventilation system typically includes a central station or fan room 11, a common supply air duct 12 connecting the central station with the ventilation zones and a common return air duct 13 connecting the ventilation zones to the central station, with each ventilation zone having a branch supply air duct 14 connected to the common supply air duct 12 and a branch return air duct 15 connected to the common return air duct 13.

The central station typically includes a central supply fan 16 mounted in the top of the common supply air duct 12, a central exhaust/return fan 17 mounted in the top of the common return air duct 13 and a set of main dampers for controlling the flow of fresh air into the common supply air duct and for controlling recycling of return air from the common return air duct 13 to the common supply air duct 12. As shown, the main dampers includes a fresh air supply damper 18 mounted in a fresh air supply duct 19 that feeds the supply fan, a main exhaust damper 20 mounted in a main exhaust duct 21 that exits from the return air duct and a return air shut-off damper 22 mounted between the supply fan 16 and the exhaust/return fan 17.

In accordance with this invention improvements are incorporated in the central ventilation system to provide for more effective fire management by isolating return air from any fire zone from return air from any non-fire zone and exhausting all of the return air from the fire zone so that the non-fire zones are not affected by any smoke or other fire conditions. In addition the non-fire zones are preferably operated at elevated pressure and the fire zones are maintained at reduced pressure to assist in isolating the fire zones.

In the illustrated embodiment of FIGS. 1 to 3 the ventilation system is provided:

with partition means 23 for dividing the common return air duct 13 lengthwise into a main return air duct section 13M and an auxiliary return air duct section 13A;

with separate branch damper means 24 for controlling communication of the branch return air duct 15 of each zone with each of the return air duct sections 13M, 13A;

with stand-by means 25 for effecting isolation and exhaust of all return air from the auxiliary return air duct section in the fire mode;

and with control means 26 which may include connections to a central control panel 27 at any suitable location in the building and which may include separate detection means 28 for each zone, the detection means being operable upon the occurrence of fire conditions for actuating the stand-by means 25 and the separate branch damper means 24 for directing all the return air from a fire zone to exhaust through the auxiliary duct section 13A and for directing all the return air from a non-fire zone into the main return air duct section 13M.

Stand-by means 25 as shown here includes the stand-by exhaust fan 29 located in the central fan room and having a backdraft damper 29D for controlling flow from the auxiliary duct section 13A to exterior atmosphere and also includes an auxiliary damper 30 located in the top of the auxiliary duct section 13A for isolating the same from both the main supply air duct 12 and from the main return air duct section in the fire mode, thereby directing all the return air from the fire zones through the stand-by exhaust fan 29.

As shown in FIG. 8 the central control panel 27 is individually connected to each of the detectors 28 and to the branch dampers 24 for automatically controlling the same and is also connected to the main dampers for automatically controlling these in the fire mode, as well as for controlling the stand-by exhaust fan 29 and the auxiliary damper 30.

It should be noted that while the partition 23 is shown centrally of the common return air duct 13 it may be located to determine a different relative size relationship between the main section and the auxiliary section. Moreover, these sections may be separate ducts rather than a dual duct as shown. It is contemplated that numerous other variations may be made in adapting the system of this invention to the requirements of a particular building or of the local fire codes.

It should also be noted that the branch dampers 24 consist of dual sections 24M, 24A located in the connection between each branch return air duct and the main and auxiliary return air duct sections 13M, 13A respectively.

During normal operating conditions, both dual damper sections 24M, 24A are open but upon activation of the detector 28 on a fire floor, the main damper section 24M is closed and the auxiliary damper section 24A is open. Simultaneously, on each of the non-fire floors the main damper section 24M is closed and the auxiliary damper section 24A is open, under the control of the corresponding detectors. Subsequent deactivation of a detector on any floor shifts the corresponding branch damper to the same position then occupied by the branch dampers on the non-fire floors until the last fire floor detector becomes deactivated when the entire system would revert to normal.

The detectors may be of any suitable type selected to respond to smoke or heat or ionization products. Depending on requirements of the local fire codes, the detectors are electrically connected to the central control panel so that when activated any detector will transmit a control pulse to the central control panel which is programmed to supply actuating signals to convert the entire system from normal mode to fire mode.

NORMAL MODE

In normal operation fresh air is drawn into the building through duct 19 to form a main supply stream in the common main duct 12; the main supply stream is subdivided into branch streams in the branch supply ducts 14 that feed each of the separate ventilation zones; return air is drawn from the ventilation zones to form a pair of common return air streams in the ducts 13M, 13A; and a portion of the return air streams is exhausted through duct 21 while the remainder is recycled into the main supply stream in duct 12. It is presently preferred that the ventilation system operate at all times to provide the minimum air movement required

to facilitate fire detection by the detector 28 in any zone.

FIRE MODE

When fire conditions are sensed by a detector 28 in any one of the ventilation zones, an electric impulse actuates the control panel 27 to reposition the components for directing all the air from any fire zone into the auxiliary return air duct 13A and through the standby fan 29 to the exterior while directing all the air from any non-fire zone into the main return air duct 13M for partial or complete exhaust as selected. During fire mode, the supply air continues to all zones and may consist of 100% fresh air or of a mixture of fresh air and return air recycled from the non-fire zones.

More specifically, for the embodiment of FIGS. 1 to 3, the activation of any detector 28 causes the control panel to isolate the auxiliary duct 13A by closing damper 30, activating the stand-by fan 29 and opening its back damper 29D, and for each fire zone closing its branch damper 24M and for each non-fire zone closing its branch damper 24A.

When any fire zone is cleared as sensed by its detector 28 while other fire zones still exist, the cleared zone has its branch dampers automatically reset to open damper 24M and to close damper 24A.

If 100 percent fresh air is to be supplied during fire mode, the recycle damper 22 is also closed and a reheat coil 31 located in the main supply duct is activated as required.

A static pressure control 32 is connected to control the capacity of the standby fan 29 to provide a variable volume capability for effecting the desired pressure reduction in the fire zone. Typically, the standby fan 29 would be provided with adjustable vanes controlled by the static pressure device to achieve this function.

Finally, a variable volume sprinkler 33 is located in the branch return duct of each zone and includes a sprinkler head and a temperature detector located at each floor line to control exhaust temperature from each fire zone.

ADDITIONAL EMBODIMENTS

A modified embodiment of a typical floor is shown in FIGS. 4 and 5 wherein the return air is drawn from a free return such as a plenum ceiling into the main and auxiliary return air duct section 13M, 13A respectively. The main damper section 24M is omitted and the auxiliary damper section 24A is open during normal operations. Operation of any separate detection means 28 in any zone upon occurrence of fire conditions therein causes an electric impulse to activate the control panel 27 to close the auxiliary damper section 24A in each of the non-fire zones and reposition the components for directing all the air from any fire zone into the auxiliary return air duct 13A and through the standby exhaust fan means 29 to the exterior.

Another embodiment as shown in FIG. 6 illustrates the partition means 23 extended into the horizontal branch return air duct 15 serving each zone to achieve horizontal sub-zoning in addition to the vertical zoning illustrated in FIG. 1. The separate branch damper means 24 for controlling communication of the branch return air duct 15 of each zone with each of the return air duct section 13M, 13A is relocated as shown to control communication of the branch return air duct 15Z within each horizontal sub-zone with each of the

branch return duct section 15M, 15A. The separate branch damper means 24 is open during normal operation. Operation of any separate detection means 28 in any sub zone upon occurrence of fire conditions therein causes an electrical impulse to activate the control panel 27 to close the auxiliary damper section 24A in all non-fire zones and sub-zones and close the main damper section 24M in the fire sub-zone and reposition all components for directing all the air from the fire sub-zone into the branch return duct auxiliary section 15A and the auxiliary return air duct 13A and through the standby exhaust fan means 29 to the exterior. All other components would operate as described for FIG. 1.

Still another embodiment, as shown in FIG. 7 utilizes a system similar to that in FIG. 1 except that the standby exhaust fan means 29 is omitted and the central exhaust/return fan 17 is replaced by two parallel fans, the non-fire area central exhaust/return fan 17M and the fire area auxiliary exhaust/return fan 17A; the dividing barrier 23 is extended into the main exhaust duct 21 dividing this duct into a general area main exhaust duct 21M and a fire area auxiliary exhaust duct 21A, controlled respectively by the general area main exhaust duct damper 20M and the fire area auxiliary exhaust duct damper 20A; the auxiliary damper 30 is retitled 30A and moved to a point just after the fire area auxiliary exhaust/return fan 17A to isolate the auxiliary return air duct section 13A and the fire area auxiliary exhaust duct section 21A, along with the fire area auxiliary exhaust/return fan 17A, from the main return air duct section 13M and the non-fire area central exhaust/return fan 17M during fire mode; the static pressure control 32 is relocated to a point just before the fire area auxiliary exhaust/return fan 17A.

Normal Operation of FIG. 7 Embodiment

The auxiliary damper 30A is wide open and the general area main exhaust duct damper 20M and the fire area auxiliary exhaust duct damper 20A operate together in conjunction with the recycle damper 22 and the fresh air supply duct damper 18 to provide fresh air as desired to the conditioned area.

Fire Mode Operation of FIG. 7 Embodiment

The auxiliary damper 30A closes and the fire area auxiliary exhaust duct damper 20A opens wide and all the air from the fire zone is exhausted to the exterior atmosphere by the fire area auxiliary exhaust/return fan 17A. The non-fire area central exhaust/return fan 17M continues to deliver return air to the central supply fan 16. The general area main exhaust duct damper 20M operates in conjunction with the recycle damper 22 and the fresh air supply duct damper 18 to provide the maximum amount of fresh air throughout the building consistent with exterior temperature and the heating capability of the reheat coil 31 to avoid freeze-ups during cold weather. The relative sizing of the two parallel exhaust/return fans 17M, 17A respectively can be varied according to local codes and design requirements as to the desired pressure differential between the fire and non-fire zones. Alternately, the non-fire area central exhaust/return fan 17M could be a two speed fan to handle, at full speed, 100 percent return air from the non-fire areas during fire mode, or, at ½ speed, 50 percent of the return air from all areas during normal mode.

Thus, while preferred constructional features of the invention are embodied in the structure illustrated herein, it is to be understood that changes and variations may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

I claim:

1. In a multi-zone building having a ventilation system that includes a central station serving a plurality of ventilation zones, common supply air duct means connecting the central station to the ventilation zones, common return air duct means connecting the ventilation zones to the central station, each zone having branch supply duct means connected to the common supply air duct means and branch return duct means connected to the common return air duct means, and the central station including central supply fan means, central exhaust/return fan means and main damper means for controlling flow of fresh air into the common supply air duct means and recycling of return air from the common return air duct means to the common supply air duct means, the improvement comprising partition means for dividing the common return air duct means lengthwise into a main return air duct section and an auxiliary return air duct section, separate branch damper means for each zone for controlling communication of the branch return duct means of such zone with each of the return air duct sections, standby means for effecting isolation and exhaust of all return air from the auxiliary return air duct section, and control means including separate detection means for each zone operable upon the occurrence of fire conditions therein for actuating the standby means and the corresponding one of said separate damper means for directing all of the return air from any fire zone to exhaust through the auxiliary return air duct section and for directing all of the return air from any non-fire zone into the main return air duct section.

2. An arrangement as defined in claim 1 wherein said standby means includes standby exhaust means having a standby damper controlling communication of the auxiliary return air duct section to exterior atmosphere, and auxiliary damper means for isolating the auxiliary return air duct section from the main supply air duct means and the main return air duct section to direct the return air in the auxiliary return air duct section to the standby exhaust means in the fire mode.

3. An arrangement as defined in claim 2 wherein the control means is automatically responsive to any of the separate detection means upon the occurrence of fire conditions in the corresponding zone for operating the auxiliary damper means to close and isolate the auxiliary return air duct section from the central exhaust/return fan means for actuating the standby exhaust means and standby damper means, for positioning the branch damper means for any fire zone so that all return air from any fire zone is directed through the auxiliary return air duct section until the corresponding fire detection means returns to normal, for positioning the branch damper means for any non-fire zone so that all return air for any non-fire zone is directed through the main return air duct section when the corresponding fire detection means are normal and for returning all equipment to normal mode when all fire detection means return to normal.

4. An arrangement as defined in claim 1 where said standby means includes variable volume standby ex-

haust means to operate at a capacity that depressurizes any fire zones and having a standby damper normally preventing communication of the auxiliary return air duct section with exterior atmosphere, and auxiliary damper means for isolating the auxiliary return air duct section from the main supply air duct means and the main return air duct section to direct the return air in the auxiliary return air duct section to the standby exhaust means in the fire mode.

5. An arrangement as defined in claim 4 and including static pressure controller means responsive to pressure in the ventilation system to control the capacity of the variable volume stand-by exhaust means to effect the desired pressure reduction in the fire zones.

6. An arrangement as defined in claim 1 wherein said control means is connected to actuate said main damper means to control delivery of as much as 100 percent fresh air to the ventilation zones during fire mode.

7. An arrangement as defined in claim 1 wherein said common supply air duct means includes air reheat means and said control means is connected to actuate said main damper means and said air reheat means to control delivery of as much as 100 percent fresh air to the ventilation zones during fire mode regardless of exterior temperature.

8. An arrangement as defined in claim 1 and including variable volume sprinkler means disposed in the auxiliary return air duct section and having a sprinkler head and temperature detector for each zone and operable for automatically controlling return air temperature from any fire zone.

9. An arrangement as defined in claim 1 wherein each of said separate damper means comprises a dual damper having a normal mode position to direct return air from the corresponding zone into both return air duct sections and having a fire mode position to direct all return air into the auxiliary return air duct section when the corresponding zone is a fire zone.

10. An arrangement as defined in claim 1 wherein the ventilation zones comprise separate floors of a multi-story building, the common supply air and return air duct means and the partition means are vertical and the branch supply and return duct means are horizontal and the central supply fan means, the central exhaust/return fan means and the main damper means are located at the top of the common supply air and return air duct means and wherein said standby means includes standby exhaust means to operate at a capacity that depressurizes any fire zones and having a connection to the auxiliary return air duct section at a location beneath the central exhaust/return fan means and having a standby damper for controlling communication of the auxiliary return air duct section to exterior atmosphere, and auxiliary damper means mounted in the auxiliary return air duct section between the said connection and the central exhaust/return fan means for isolating the return air duct section from the main supply air duct means and the main return air duct section to direct the return air in the auxiliary return air duct section to the standby exhaust means in the fire mode.

11. A method of fire control and ventilation for multi-zone buildings comprising: drawing fresh air into the building to form a main supply air stream; subdividing the main stream into branch streams each leading into a separate zone; drawing return air from the zones to form a main return air stream and an auxiliary return

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air stream; normally exhausting some of the air from the return air streams while recycling the remainder into the main supply air stream; and isolating the return air streams in response to fire conditions occurring in any zone by exhausting all of the auxiliary return air stream while directing all return air from any fire zone into the auxiliary return air stream and directing all return air from any non-fire zone into the main return air stream.

12. A method in accordance with claim 11 wherein exhaust of all of the auxiliary return air stream in response to fire conditions is effected at a rate to produce a multifold increase in return air from any fire zone.

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13. A method in accordance with claim 11 and including the step of sensing the pressure in the ventilation system during fire conditions and controlling the exhaust of the auxiliary return air stream in accordance with the pressure in the system to effect a pressure reduction in any fire zone relative to any non-fire zone.

14. A method in accordance with claim 11 and including supplying 100 percent fresh air to all zones during the existence of fire conditions while effecting a pressure reduction in any fire zone relative to any non-fire zone.

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